VII. *Obſervations of a new variable Star. In a Letter from* Edward Pigott, *Eſq. to Sir* H. C. Englefield, *Bart. F. R. S. and A. S.*

Read December 23, 1784.

DEAR SIR,

FOR ſome years paſt I have been employed in verifying all the ſtars ſuſpected to be variable, in order that hereafter we may know with certainty what to depend upon. This undertaking, which is nearly completed, has already proved of uſe in detecting many miſtakes, and producing ſome diſcoveries; among which, the following is one of the moſt important. September 10, 1784, I firſt perceived a change in the brightneſs of the ſtar η Antinoi, and by a ſeries of obſervations made ever ſince, I find it ſubject to a variation very ſimilar to that of Algol, though not exactly the ſame in any one particular.

η Antinoi, when brighteſt, is of the third or fourth magnitude, being between δ and β Aquilæ; and at its leaſt brightneſs of the fourth or fifth magnitude, it then being between that of ι Antinoi and μ Aquilæ; therefore, its greateſt variation in brightneſs may be called about one magnitude; and the changes it undergoes, though probably not nicely aſcertained from ſo few obſervations, are nearly theſe:

At its greateſt brightneſs	44 ± hours.
In decreaſing - -	62 ± hours.
At its leaſt brightneſs	30 ± hours.
In increaſing - -	36 ± hours.

All theſe changes, which hitherto ſeem to be regular and conſtant, are performed in 7 days 4 hours 38—minutes; this I ſhall ſtile its period, and hereafter will ſhew how it is determined with ſuch exactneſs.

The ſtars to which η Antinoi was compared are in order thus: δ Aquilæ third magnitude, β Aquilæ and θ Serpentis fourth magnitudes, ι Antinoi fourth or fifth magnitude, and μ Aquilæ a bright fifth. I find, by ſeveral years obſervation, that β Aquilæ retains the ſame brightneſs. ι Antinoi, which has been examined with particular attention by Mr. Goodricke and myſelf, is ſuſpected by us both to be ſubject to a ſmall variation, but not ſufficiently apparent, ſo as to affect materially theſe compariſons, and poſſibly it may be only the effect of ſome optical illuſion; for I have frequently remarked, that both in the twilight and moon-light, or when the air is in the leaſt hazy, there is a greater difference between the brightneſs of many of the ſtars, than in a dark night and clear ſky.

In the following journal of obſervations of η Antinoi, the Greek letters β, δ, μ, belong to Aquila, and ι, ν, to Antinous; ſecondly, the magnitudes marked in column the third are by eſtimation, and can be of no further uſe than merely to give, at firſt ſight, an idea of the ſtar's brightneſs; and laſtly, the lines diſtinguiſhed by inverted commas, are extracts from Mr. Goodricke's journal, whoſe friendly aſſiſtance I have often experienced, and was the more welcome on this occaſion, becauſe repeated attention and great exactneſs were requiſite.

Dates.

Dates. 1783.	Hours.	Magnitude.	Journal of the comparative brightneſs of η Antinoi.
July 17	10±	3 . 4	Leſs than δ Aquilæ and brighter than θ Serpentis (β Aquilæ and θ Serpentis are equal) weather hazy.
19	10±	4	Rather brighter than β Aquilæ and θ Serpentis.
27	10±	4	If any difference, leſs than β Aquilæ. N. B. Theſe times are from recollection, and cannot err more than 1½ hour.
1784			
Sept. 10	10±	4	Leſs than β Aquilæ and θ Serpentis.
12	7½	4 . 5	Much leſs than β, equal to ι.
—	9	4 . 5	" A little brighter than ι, air clear."
13	7½ 9½	3 . 4	Leſs than δ, brighter than β, and much brighter than ι.
—	8	3 . 4	" Brighter than ι and β."
15	8	4	Rather brighter than β, and much brighter than ι.
18	9½ 11	4 . 5	" Leſs than β and ι."
19	7½	4 . 5	Much leſs than β, and equal to ι.
—	7 9	4 . 5	" Leſs than β and ι."
20	8	3 . 4	Brighter than β and ι; at 11 h. it ſeemed to have increaſed.
23	7½ 8	3 . 4	Leſs than δ, rather brighter than β; thought it rather leſs at 11½ h.; moon near.
28 29	9±	3 . 4	Brighter than β; moon-light.
30	9±	3 . 4	If any difference, rather brighter than β.
—	9±	3 . 4	" Rather brighter than β."
Oct. 1	7 9	4	Leſs than β, brighter than ι; air clear, moon-light.
2	8	4 . 5	Equal to ι, much leſs than β.
—	8	4 . 5	" Leſs than ι."
5	8	3 . 4	Between the brightneſs of β and δ.
6	9±	3 . 4	" Brighter than β and ι."
7	7½ 9¾	3 . 4	Rather brighter than β.
—	8±	3 . 4	" Much the ſame as yeſterday."
8	8±	4	Brighter than ι; think it not leſs than β; this obſervation doubtful, occaſioned by intervening clouds.
—	8±	4 . 5	" Believe it leſs than ι; weather bad."
9	8±	4 . 5	" Certainly leſs than β; weather bad."
10	11	4 . 5	" Leſs than ι; rather a doubtful obſervation."
11	10½	4	Rather leſs than β, and brighter than ι.
15	10	4	Equal to β.
—	8±	4	" Rather brighter than β."
16	8	4	Leſs than β, brighter than ι.

Dates. 1784	Hours.	Magnitude.	Journal continued.
Oct. 16	6½	4 . 5	" Leſs than β and ι."
17	7 8	4 . 5	Undoubtedly leſs than ι.
18	8	4 . 5	Leſs than ι, brighter than μ.
—	6½	4 . 5	" Leſs than ι."
19	7½	3 . 4	Evidently brighter than β.
20	8±	3 . 4	" Much brighter than β."
22	8±	3 . 4	" Brighter than β."
23	6½	4	Leſs than β.
—	8	4	" Not ſo bright as β, brighter than ι."
24	7	4 . 5	Equal to ι, much leſs than β; moon-light, air clear.
—	6½ 7	4 . 5	" Leſs than ι; rather, though very little, brighter than μ."
25	6¾	4 . 5	Much leſs than β, equal to ι, brighter than μ.
26	6½	4	Sometimes ſeemed rather leſs, but generally equal to β.
—	9¼	4	Equal, if not rather brighter than β.
—		4	" At 6½ rather leſs, at 8½ nearly equal, and at 9½ " rather brighter than β.".
27	6	3 . 4	Remarkably bright, nearer δ than β; moon-light, air clear.
—	6½	3 . 4	" Nearer to β than to δ."
31	8¼	4	Seemed equal to β; air not very clear.
Nov. 3	5½	3 . 4	" Rather brighter than β."
6	8½	4	Evidently leſs than β.
7	9	4 . 5	Much leſs than β.
—	7½	4 . 5	" Leſs than β and ι."
11	7	3 . 4	Brighter than β, much leſs than δ.
12	6½	3 . 4	Rather brighter than β, certainly equal.
—	8½	3 . 4	" Rather brighter than β and ι."
13	5½ 7	4 . 5	Leſs than β, equal to ι.
—	7	4 . 5	" Leſs than β, and rather leſs than ι."
16	5¾	4	Evidently leſs than β, and rather brighter than ι; at 8 it ſeemed increaſed, and about
—	8	4	Between its leaſt and full brightneſs.
—	7	4 . 5	" Leſs than β, and ſomething leſs than ι."
17	5¾ 7¼	3 . 4	Brighter than β.
19	6	4	If any difference, rather brighter than β; clouds covered the moon:
—	8	4	at 8h. if any difference rather leſs than β; moon-light, and air not ſo clear as at 6.
—	6	4	" Rather brighter than β, brighter than ι."
20	7	4	Rather leſs than β, brighter than ι.
21	6¾	4	Leſs than β, rather brighter than ι; moon-light.
25	7	3 . 4	" Brighter than β."
Dec. 4	6½	4	If any difference, leſs than β.

In order to obtain a point of compariſon, for ſettling the periodical changes of η Antinoi, which I ſuppoſe to be conſtant, it is natural to fix upon that phaſis, which can be determined with the greateſt preciſion; and this ſeems to be at the time when it is between its leaſt and greateſt brightneſs, as *almoſt the whole* increaſe of brightneſs is completed in leſs than 24 hours, though the perfect completion is performed only in 36 ± hours; thus having ſettled this neceſſary point, and found roughly the length of a ſingle period, the computations, in order to obtain greater exactneſs, are as follows.

Time when η Antinoi was between its leaſt and greateſt brightneſs.	Intervals between the obſervations.		Number of periods in ditto.	Length of a ſingle period.	
Hours.	Days.	Hours.		Days.	Hours.
1784, Sept. 12. at 20 Oct. 11. at 11	28	15	4 each of	7	3¾
Sept. 12. at 20 Oct. 18. at 20	36	0	5 D°	7	4¾ +
Sept. 12. at 20 Oct. 26. at 00	43	4	6 D°	7	4¾ −
Sept. 12. at 20 Nov. 16. at 8	64	12	9 D°	7	4
Sept. 19. at 20 Oct. 18. at 20	9	0	4 D°	7	6
Sept. 19. at 20 Oct. 26. at 00	36	4	5 D°	7	5½ +
Sept. 19. at 20 Nov. 16. at 8	57	12	8 D°	7	4½
Oct. 11. at 11 Nov. 16. at 8	35	21	5 D°	7	4¼ −
Oct. 18. at 20 Nov. 16. at 8	28	12	4 D°	7	3
Length of a ſingle period, on a mean,				7	4. 30

Perhaps other aſtronomers may not exactly agree with me, in fixing the times as ſet down in column the firſt; for my part, I determined them without paying any regard to the reſults, by taking a medium between the times when η Antinoi had

had rather paſſed its leaſt brightneſs, being nearly equal to ι Antinoi, and when it was a little, but undoubtedly, brighter than β Aquilæ. Though it does not appear, as I have already ſaid, that any of the other phaſes can be ſettled with equal preciſion, different compariſons nevertheleſs may prove ſatisfactory towards corroborating the above; I have therefore alſo deduced its period from the beſt and moſt diſtant obſervations, made when at its leaſt brightneſs; they are thus: 7 days 0 hours and 7 days 5 hours. Theſe reſults I reject, and retain the mean given by the firſt ſet, with which we may proceed on to gain a much greater exactneſs; let one period be ſubtracted from the obſervation of July 27th, 1783, and it will appear, that η Antinoi had varied in brightneſs during the following four days, though at that time it did not ſtrike me.

1783, July 17th, decidedly brighter than β Aquilæ.
— 18th, not obſerved.
— 19th, rather brighter than β Aquilæ.
— 20th (anſwering to the 27th) equal or rather leſs than β Aquilæ.

As it is therefore evident, that on July 19th and 27th, 1783, η Antinoi was *decreaſing* in brightneſs, I ſhall compare thoſe days obſervations to correſponding ones made in 1784.

	Hours.	
1784, Sept. 30. at	6	Similar obſervations to that of 1783 July 19th, at 10 h. ±, η Antinoi being rather brighter than β Aquilæ.
Oct. 7. at	16	
Oct. 15. at	6	
Oct. 22. at	12	
Nov. 12. at	2	
Nov. 19. at	00	

Hours.
1784, Sept. 30. at 18
Oct. 15. at 14
Oct. 22. at 19
Nov. 12. at 14
Nov. 19. at 14
} Similar Obſervations to that of 1783, July 27th, at 10 h. ±, η Antinoi being equal to or rather leſs than β Aquilæ.

In eſtimating the above times, I paid much attention to the obſervations of the preceding and following days; however, a few hours more or leſs do not make a material difference. The reſults of theſe compariſons are

	D.	H.	M.
	7	4	39½
	7	4	44½
	7	4	53⅓
	7	4	54⅔
	7	4	32
	7	4	26½
	7	4	32
	7	4	42½
	7	4	43−
	7	4	26
	7	4	21½
On a mean	7	4	38− length of a ſingle period.

As this approaches the moſt to the preceding reſult, it may be aſſumed as neareſt the truth, provided the changes be uniformly periodical.

Hitherto the opinion of aſtronomers concerning the changes of Algol's light ſeem to be very unſettled; at leaſt none are univerſally adopted, though various are the hypotheſes to account for it; ſuch, as ſuppoſing the ſtar of ſome other than a ſpherical a ſpherical form, or a large body revolving round it, or with ſeveral dark ſpots or ſmall bright ones on its ſurface, alſo giving an inclination to its axis, &c.; though moſt of theſe conjectures with regard to Algol be attended with difficulties, ſome of them combined do, I think, account for the variation of η Antinoi.

Thoſe perſons who are accuſtomed to examine the ſtars attentively will not be ſurpriſed to find, that Mr. Goodricke and I do not always perfectly agree in our obſervations; theſe ſmall differences in the magnitudes of the ſtars are very difficult to be aſcertained with the naked eye, which has often made me lament, we had not ſome contrivance for determining their relative brightneſs, and even I attempted ſeveral methods, but did not purſue them with ſufficient attention and diligence to obtain any ſatisfactory reſults; nevertheleſs I ſhall juſt mention them, as perhaps ſomebody elſe may overcome thoſe difficulties, which to me appeared ſo very conſiderable.

1. In 1778 I had ſmall pieces of fine glaſs ſtained with different ſhades, which being applied to the eye end of a teleſcope, I could eaſily find what degree of ſhade was requiſite to efface ſtars of different brightneſs; and thus I obſerved ſome of the ſtars and planets.

2. Diaphragms were attempted; but, beſides other difficulties, they did not efface ſtars of the firſt magnitude.

3. A method which pleaſed me much, and perhaps may not prove unſucceſsful, is, by putting the ſtars out of the focus of a teleſcope till they become inviſible; this is performed by drawing the eye-tube of a refractor either in or out; the point of focal diſtance being previouſly determined, the brighter the ſtar the greater length of tube muſt be ſlid either in or out to efface it; thus I was in hopes of determining their magnitudes,

tudes, and for that purpoſe had in 1776 diviſions engraved on the eye-tube of a refractor; but found that its high magnifying powers prevented ſtars of the firſt and ſecond magnitude becoming inviſible.

Laſtly, I am inclined to think the following method practicable, *viz.* to reflect in a teleſcope, by means of an illuminator, different degrees of light in a known proportion, ſo that ſtars of all magnitudes may be obliterated.

The changeable ſtate of the weather will perhaps be thought a conſiderable obſtacle to theſe contrivances, and to throw doubt on the obſervations; but this may be ſufficiently obviated by attending to ſmall teleſcopic ſtars, which according to the clearneſs of the atmoſphere are more or leſs diſtinctly ſeen.

I beg the favour of you, dear Sir, to preſent theſe obſervations to the Royal Society; and believe me, with the greateſt regard, &c.

York, Dec. 5, 1784. EDWARD PIGOTT.